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ORIGINAL PAPER

Effect of different pre-sowing treatments on seed germination percentage and growth performance of *Acacia auriculiformis*

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Abstract: Seed morphology, germination and seedlings growth of *Acacia auriculiformis* were studied. The experiment was conducted in the nursery of Forestry and Wood Technology Discipline, Khulna University, Bangladesh. Matured seeds of the species were collected from healthy trees of road side plantation from different areas of Khulna District, Bangladesh and treated with five pre-sowing treatments (control, immersion in cold water, immersion in hot water, scarification with sand paper and immersion in concentrated H_2SO_4). The average length, breadth and thickness were found to be (0.58±0.017) cm, (0.44±0.007) cm and (0.20±0.089) cm, respectively. Germination was conducted in polybags with a mixture of top soil, coconut husk, coarse sand, and fine sand in a ratio of 3:4:1:1. Results reveal that pre-sowing treatments influences the germination rates of seeds that significantly increase the percentage germination compared with those in control (43%) and cold water treatment (52%). The highest germination success rate was found 83% in hot water treatment followed by 78% in scarification with sand paper, and 75% with immersion in H_2SO_4. Germination started from 7 to 12 days and completed between 28 and 35 days period in all treatments. ANOVA showed the significant difference ($p<0.05$) among the treatments in seed germination, but no significant difference among treatment with regard to starting day, closing day and total germination period. In case of height and diameter growth, seedlings originated from the seeds with hot water treatment shows significantly higher in wet season (from May to July). Hot water treatment can be recommended on seed germination of the species in rural Bangladesh.

Keywords: seed germination; seed dormancy; pre-sowing treatment; seedling growth; *Acacia auriculiformis*

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Introduction

Acacia auriculiformis A. Cunn. ex Benth. (family – *Fabaceae*) is a multi-purpose, leguminous tree in the subfamily *Mimosoideae* and widely distributed in many tropical countries in South and Southeast Asia, Africa and Latin America (Das and Alam 2001). It is a colonizing species in its native habitats, which provides initial crown cover and shedding for the establishment of rain forest (Zabala 1990). *A. auriculiformis* is introduced as an exotic species in Bangladesh, as natural forests are shrinking rapidly due to encroachment and illicit felling resulting from serious population pressure (Bhuiyan 1979; ADB 1992). However, there is some controversy of *Acacia* cultivation in plantation programme in Bangladesh based on media reports that the species has some damaging impact on the ecosystem, but the decision is not supported by sufficient scientific information, research or field experiments. Nevertheless, pollen allergy of *A. auriculiformis* is not proved as a serious problem in the context of Bangladesh. *A. auriculiformis* an attractive fast-growing (Duke 1981; Das 1985) tree is planted for fuel wood production and erosion control (NAS 1979). It is also planted as an ornamental, shade bearer, sources of pulp and tannin producing plant in many tropical areas in the world (NAS 1979). For its rapid growth, the ability to fix nitrogen, and the tolerance of infertile, acid, alkaline, saline or seasonally waterlogged soil, and of moderate dry seasons make it a very useful species for rehabilitation of degraded lands (Latif et al. 1985; Hossain et al. 1997). *A. auriculiformis* has been already proved successful for afforestation, reforestation and agroforestry programme in Bangladesh because of its growth, short rotation, non-palatability to grazing animals and specially its ability to thrive in poor soil (Hossain et al. 1989 and 1994; Amin et al. 1995). Cultivation of this species should be considered and farmer's choice in the selection of the species should be given preferences. In Bangladesh, *A. auriculiformis* is widely used in home garden, road side plantation both in public and private plantation programs. Plantation of *A. auriculiformis*

tree improves the environmental condition of the country and enriches soil condition through nitrogen fixation. It gained a favorable reputation as a good covers crop of tea in land reclamation, erosion control, and water conservation. The leaves can be used as mulch around other crops (Duke 1981). *A. auriculiformis* tree with its own importance can meet the demand of fuel wood, poles and timber because of acute shortage of timber and fuel wood in Bangladesh. So, it can be introduced in all over the country especially in degraded fallow lands. But seed germination of these species is very poor and difficult to germinate, even if it is supplied with the suitable environment for germination (Zabala 1991). Seed treatment is to ensure to both enhance and uniform germination (Azad et al. 2006a). The effect of pre-sowing treatments on seed germination of some tropical forest tree species are reported (Ahamed et al. 1983; Matin and Rashid 1992; Bharwas and Chakraborty 1994; Ali et al. 1997; Koirala et al. 2000; Khan et al. 2001; Alamgir and Hossain 2005a and 2005b; Matin et al. 2006; Azad et al. 2006a, 2006b, 2010a and 2010b). However, there are few documents available on the effect of pre-sowing treatment of *A. auriculiformis*. Intensive plantation in agroforestry, social forestry and home garden is restricted due to destitute seed germination and delayed nursery establishment (Alamgir and Hossain 2005b; Azad et al. 2006a and 2006b). Germination percentages can be increased through adopting suitable pre-sowing techniques (Maguire 1962; Koirala et al. 2000; Alamgir and Hossain 2005a and 2005b; Azad et al. 2006a, 2006b, 2010a and 2010b). Therefore, the study attempts to determine the best possible pre-sowing treatment method that maximizes the germination percentages and seedlings growth performance at the nursery stages.

Materials and methods

Study area

The experiment was carried out in the nursery of Forestry and Wood Technology Discipline, Khulna University, Bangladesh, located in the south-western part of Bangladesh. It is the part of the largest delta. The Sundarbans lies in the southern part of the delta, and it is the largest unit mangrove forest in the world. The study area is situated about 4 m above sea level. The geographic position of the study area is situated between 22°12' N–23°59' N and 89°14' E−89°45' E. The climate of the study area is known as sub-tropical in nature, like the other part of the country. Winter, summer and monsoon, the three main seasons distinguish here. Relatively mild winter starts from November to the end in February, but the temperature fluctuation during the winter is very low. Temperature falls to 7–12°C in winter and raises up to 25–32°C in summer, but very occasionally it might be increase up to 36–40°C. The mean monthly temperature is about 28°C. The summer is from March to June. The monsoon starts from July and continues until October (BBS 1993; Alam et al. 2005). The air temperature and relative humidity were recoded 21–27 °C and 60%–85%, respectively, during the experiment.

Plant materials and Design of the experiment

The seeds were collected from 20 to 30 years old matured and healthy trees (according to the plantation journals of forest division and NGOs) from different areas of Khulna District, Bangladesh during the month of January 2008. The mature pods were collected from the road side plantation manually with bags and baskets, and then dried at the sun for 2–3 days. The seeds were then extracted from the pods manually 2–3 days after collection. The seeds were dried to reduce the moisture for 3–4 days in the open sun. Healthy dried seeds were used for the experiment. The germination test was done by sowing the seeds in poly-bags (4 cm × 6 cm). The media of the poly-bags was topsoil, coconut husk compost, coarse sand and fine sand in the ratio of 3:4:1:1. There were five treatments in the experiment, i.e., control, immersion in the cold water (4°C) for 12 hours, immersion in the hot water (80°C) for 10 min, scarification with the sand paper, and immersion in the concentrated H_2SO_4 (80%) for 20 min. The treatments were based on Azad et al. (2006a) who modified the treatment of Kobmoo and Hellum (1984). One seed was sown in each polybag. Polybags were kept in shade throughout the experiment. The seeds were sown at a depth of 0.5−1.5 cm and was watered manually once a day. Randomized Block Design (RBD) with four replications was used for the experiment. 80 polybags (4×20) were used for each treatment and the total numbers of poly bags is 400 (5×4×20).

Germination percentages estimation

The number of seeds germinated in each treatment was recorded on every alternate day. The starting and finishing dates of germination were also recorded. At the end of the germination period, the germination percentage and germination rate (Maguire 1962) was calculated using the following equations:

$$\text{Germination Percentages (\%)} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds sown}} \times 100 \quad (1)$$

Growth performance

After the completion of seed germination experiment, the growth performance of the seedlings was monitored for 180 days to assess the pre-sowing treatment effect on growth. All the seedlings were measured for total shoot height and collar diameter once in a month. Total shoot height was measured by using ruler and collar diameter by using electronic digital caliper (6"/150 mm, accuracy ± 0.02 mm, LR44, 2006/66/EC). The experiment was carried out during January to July 2008.

Data Analysis

Analysis of variance (ANOVA) and Duncan Multiple Range Test (DMRT) (Duncan 1955) were carried out for data analysis. Data were analyzed by using MS Excel and SPSS ver.10 to explore possible treatment variation. Analysis of variance was carried out to determine the treatments effect on seed germination percentage,

and height and diameter of the seedlings. DMRT was used to compare mean germination percentages, height and diameter in each pre-sowing treatment.

Results

Morphological characteristics of seeds

The fresh seeds of *A. auriculiformis* were reddish brown in color and whitish upon dry. The average length, breath and thickness of the seeds were (0.58±0.017) cm, (0.44±0.007) cm and (0.20±0.089) cm, respectively.

Seed germination

Germination started earlier in the hot water (T3), scarification with sand paper (T4) and immersion in concentrated H_2SO_4 treatment (T5) than in control (T1) and cold water treatment (T2) (Table 1). Germination closed earlier in concentrated H_2SO_4 treatment (T5) than in control (T1), cold water (T2), hot water (T3) and scarification with sand paper treatment (T4). An average of 35 days was taken to complete the seed germination in control while it was completed 7 days earlier in concentrated H_2SO_4 (80%) for 20 min. In all treatments, germination completed with in 28−35 days after sowing the seed in polybag (Table 1). Analysis of variance showed no significance difference in germination starting days, germination closing days and germination period among the treatments. The highest germination success (83%) in hot water treatment differed significantly ($p<0.05$) with the lowest germination success (43%) in control. Germination in scarification with sand paper (78%), immersion in H_2SO_4 (concentrated) for 10 min (75%) showed no significant difference ($p>0.05$) with each other. But they differed significantly ($p<0.05$) with control (43%) and cold water treatment (52%) (Table 1). Duncan Multiple Range Test (DMRT) showed significance difference of seed germination in the hot water treatment with other treatments but no significant difference of seed germination between scarification with sand paper treatment and H_2SO_4 treatment. Furthermore, they differed significantly with control and cold water treatment. It also showed there was significant difference between control and cold water treatment (Table 1). The cumulative germination success (%) of *A. auriculiformis* under different pre-sowing treatment was shown in the Fig. 1.

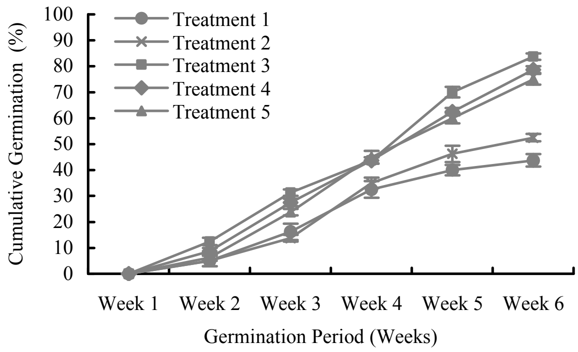

Fig. 1 Cumulative germination (%) through out the germination period of *A. auriculiformis* under five pre-sowing treatments in polybag. T1: Control, T2: Immersion in cold water (4°C) for 12 h, T3: Immersion in hot water (80°C) for 10 min, T4: Scarification with sand paper, T5: immersion in concentrated H_2SO_4 (80%) for 20 min.

Table 1. Summery of different pre-sowing treatment effects on seed germination period, germination percentage, height and diameter growth of *A. auriculiformis* at nursery stages.

Pre-sowing treatment	Germination Start (Days)	Germination Cease (Days)	Total Germination Period (Days)	Total Germination (%)	*Mean Height Growth (cm)	*Mean Collar Diameter (cm)
T1	12.25±0.48	47.25±0.47	35±0.71	43.75±2.39c	12.91±1.67b	0.17±0.024b
T2	11.50±0.29	42.25±0.63	30.75±0.85	52.50±1.44c	13.24±1.74b	0.18±0.024b
T3	7.25±0.25	39.0±0-41	31.75±0.47	83.75±1.25a	17.65±2.88a	0.24±0.035a
T4	8.0±0.41	41.75±0.48	33.75±0.63	78.75±1.25b	14.31±2.01b	0.19±0.022b
T5	8.50±0.64	36.5±0.50	28±1.08	75±2.04b	13.92±1.77b	0.20±0.023b

Same letter(s) in the same row indicates insignificant different and ± indicates standard error at $p<0.05$.

*: growth / month; T1: Control, T2: Immersion in cold water (4°C) for 12 h, T3: Immersion in hot water (80°C) for 10 min, T4: Scarification with sand paper, T5: immersion in concentrated H2SO4 (80%) for 20 min.

Growth performance of Seedlings

Height of the seedlings of *A. auriculiformis* originated from the seeds treated with different pre-sowing treatments was determined at nursery stages (Fig. 2). At the end of 6 months, height of seedlings originated from seeds with hot treatment significantly ($p<0.05$) higher than other treatments. Analysis of variance showed significance difference of height of seedlings ($p<0.05$) originated from seeds among the pre-sowing treatments. Duncan Multiple Range Test (DMRT) shows significance difference of height of seedlings originated from seed with hot water treatment with other treatments but no significant difference of height of seedlings among control, cold water, scarification with sand paper treatment and H_2SO_4 treatment (Table 1).

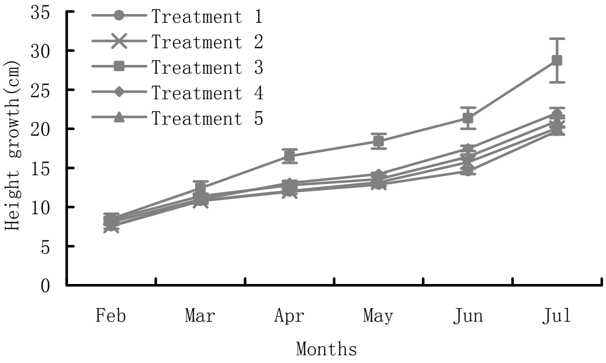

Fig. 2 The effect of pre-sowing treatments of height of *A. auriculiformis* seedlings under five pre-sowing treatments in polybag at nursery stages. T1: Control, T2: Immersion in cold water (4°C) for 12 h, T3: Immersion in hot water (80°C) for 10 min, T4: Scarification with sand paper, T5: immersion in concentrated H_2SO_4 (80%) for 20 min.

Diameter of seedlings

Collar diameter of the seedlings of *A. auriculiformis* originated from the seeds treated with different pre-sowing treatments was also determined at nursery stages (Fig. 3). At the time of seedling observation at the nursery, it was found that collar diameter of seedlings with hot treatment significantly (p<0.05) higher than that of other treatments. Analysis of variance shows significance difference of diameter of seedlings originated from seeds (p<0.05) among the pre-sowing treatments. Duncan Multiple Range Test (DMRT) showed significance difference of diameter of seedlings originated from seed with hot water treatment and other treatments but no significant difference of diameter of seedlings among control, cold water, scarification with sand paper treatment and H_2SO_4 treatment (Table 1).

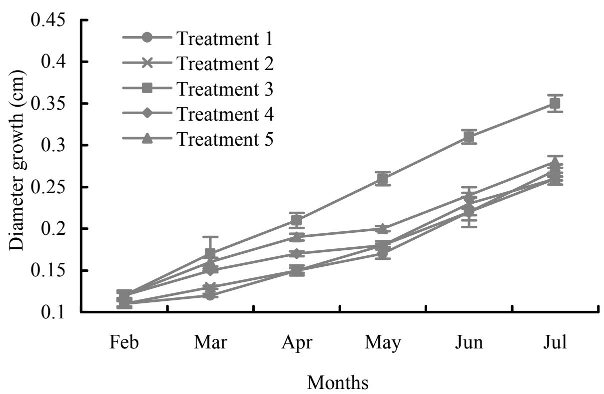

Fig. 3 The effect of pre-sowing treatments of collar diameter of *A. auriculiformis* seedlings under five pre-sowing treatments in polybag at nursery stages. T1: Control, T2: Immersion in cold water (4°C) for 12 h, T3: Immersion in hot water (80°C) for 10 min, T4: Scarification with sand paper, T5: immersion in concentrated H_2SO_4 (80%) for 20 min.

Discussion

Different methods of pre-sowing treatments of seed germination to break seed dormancy, thereby, to increase the germination rate and speed up the germination process were argued by several authors (Kobmoo and Hellum 1984; Khasa 1992; Yadav 1992; Teketay 1996; Alamgir and Hossain 2005a and 2005b; Azad et al. 2006a and 2006b; Airi et al. 2009; Azad et al. 2010a and 2010b). Seed dormancy can vary from species to species, stage of maturity of seed and degree of drought, etc.. Therefore, pre-treatment should be adjusted accordingly (Amen 1968; Rees 1996). Physical seed dormancy may be defeated either by physical scarification of seed coat by clipping, nicking, piercing, flaming or filing with the aid of needle, knife, hot wire burner, and abrasion paper etc. (Catalan and Macchiavelli 1991; Schmidt 2000). Equally, acid treatment (Kobmoo and Hellum 1984) or hot water treatment (Kobmoo and Hellum 1984; Khasa 1992; Airi et al. 2009) can also conquer physical seed dormancy. Generally, the untreated drupes germinate slowly and irregularly (Jackson 1994; Hossain et al. 2005). The seeds with hard, solid, inflexible seed coat were reported to recover germination with pre-sowing treatments (Kariuki 1987; Palani et al. 1996; Hossain et al. 2005). Furthermore, the findings of the present study show that seeds of *A. auriculiformis* under different treatments can improve seed higher germination success significantly (p<0.05) than under other treatments. Hot water (80°C for 10 min) treatment shows the best germination success (83%) among the five pre-treatments of seeds germination. The second, third and fourth highest germination was found in scarification with sand paper (78%), concentrate H_2SO_4 (75%) and cold water (52%). The lowest germination success (43%) was found in control condition. DMRT shows no significant difference between the treatments of scarification with sand paper and H_2SO_4 treatments but they differ from hot water treatment. It may be due to the outer coat of the seeds were more or less equally thinned but not properly, thus, the germination takes place at a similar pattern in scarification with sand paper and H_2SO_4 treatments, but the immersion in hot water (80°C for 10 min) treatment may be thinned the seed coat properly. Azad et al. (2006b) carried out an experiment on different pre-sowing treatment effect on seed germination on *Xylia carrii* in Bangladesh. They found the similar result in hot water treatment (87%). Azad et al. (2010a) found 69% germination success in hot water (80°C for 10 min) treatment on *Melia azedarach*. It may be due to the difference of seed coat thickness. Ali et al. (1997) carried out an experiment on hot water treatment (50°C and boiling for 3 min) on *A. procera* and found 43% seed germination. Alamgir and Hossain (2005b) showed that hot water (immersion in boiled water 1 min, and then flowed cold water treatment for 24 h), cold water and nail clipping (one side of the seeds) treatments on *Albizia saman*. They found highest germination success in nail clipping (50%) followed by hot water treatment (20%). The difference of germination percentages may be due to the difference of temperature and the boiling time. It clearly shows that the seed coat of *A. auriculiformis* soften at 80°C for 10 min. Azad et al. (2006a)

reported highest germination (52%) in hot water treatment in *A. lebbeck* may be due to the variation of seed coat thickness.

In case of height and collar diameter, seedlings originated from seeds with hot water treatment show better growth in wet season (May–July). The seedlings originated from scarification with sand paper, immersion in concentrated H_2SO_4, cold water and control showed second, third, fourth and fifth position of height growth of seedlings but in case of collar diameter growth concentrated H_2SO_4, scarification with sand paper, cold water treatment and control condition showed second, third, fourth and fifth position. During the wet season (May–July), there is a sharp increase in height and diameter growth of seedlings. This increase in height and collar diameter of seedlings during wet season may be due to the adequate rain fall in this period. The rain increases the soil moisture in the polybag, and the seedling originated from seeds with hot water treatment are able to absorb much water than others. Similar observations were found in forest tree seedlings at nursery stages (Matin and Banik 1993). Matin and Rashid (2000) also reported better height and diameter growth of seedlings of some multipurpose tree species at nursery stages in wet season than semi-wet and dry season. Matin et al. (2006) mentioned height growth of seedlings of *Dalbergia sissoo* originated from seed without seed coat condition perform better then that of having seed coat in wet season. This may be due to higher moisture absorption by the plants of without seed coat condition during wet season.

Conclusion

Acacia auriculiformis is an important tree species for social forestry and agroforestry program due to its rapid growth and capability of nitrogen fixation. It can also tolerate infertile, acid, alkaline, saline or seasonally waterlogged soil, which makes it a very useful species for rehabilitation in degraded fallow lands. Thus, the species is very interesting to determine appropriate seed germination techniques. Among the pre-sowing treatments, seed germination under immersion in hot water performs significantly well than others, though the performance of seed germination by the treatments of scarification with sand paper and sulphuric acid were not bad. Nevertheless, the use of sulphuric acid and scarification techniques are somewhat risky and problematic. Seed germination under hot water treatment is quite simple and inexpensive. Beside, seedling growth originated from hot water treatment performed significantly higher than others. Therefore, it is suggested to apply hot water treatment on seed germination for *A. auriculiformis* in Bangladesh for social forestry and agroforestry program.

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